



SELECTED MANAGEMENT CONCEPTS IN SUPPLY CHAINS

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Abstract

Supply chain management is considered a complex process that can lead to errors, conflicts, or a breakdown of cooperation. In chain creation, it is important to organize and rationalize the network of interconnections to which the assumptions of concepts, such as lean manufacturing, agile manufacturing, and resilient supply chains, can be applied. For this reason, the aim of the research presented in the study was to attempt to identify how selected management systems in supply chains can influence the improved functioning of enterprises in a vulnerable condition and in the contemporary challenging situation. The starting point for consideration was to define the concept of a supply chain, lean manufacturing, agile manufacturing, and resilient supply chains, and to indicate the benefits of using the selected concepts. For this purpose, foreign and domestic literature was used. The result is a description, analysis, and criticism of the different systems in relation to the supply chain.

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Abstrakt

Zarządzanie łańcuchem dostaw jest uznawane za skomplikowany proces, który może prowadzić do powstawania błędów, konfliktów lub rozpadu współpracy. Istotne w tworzeniu łańcuchów jest uporządkowanie oraz racjonalizacja sieci wzajemnych powiązań, do których można odnieść założenia takich koncepcji, jak: *lean manufacturing*, *agile manufacturing* oraz *resilient manufacturing*. Z tego względu celem badań przedstawionych w opracowaniu była próba wskazania, jak wybrane systemy zarządzania w łańcuchach dostaw mogą wpływać na poprawę funkcjonowania przedsiębiorstw w warunkach zagrożenia oraz współczesnych wyzwań. Punktem wyjścia rozważań było zdefiniowanie pojęć: łańcuch dostaw, *lean manufacturing*, *agile manufacturing* oraz *resilient manufacturing*, a także wskazanie korzyści płynących z zastosowania wybranych koncepcji. W tym celu skorzystano z literatury zagranicznej oraz krajowej. Rezultatem tych działań jest opis, analiza oraz krytyka poszczególnych systemów w odniesieniu do łańcucha dostaw.

Introduction

In the rapidly developing economy of the XXI century, enterprises engaged in production or services are facing many challenges presented to them not only by consumers, but also by the market and geopolitical conditions. Regarding the manufacturing or service activities of enterprises, there are more and more threats and disruptions (this is particularly evident in the case of the coronavirus pandemic from 2020) (Morley, 2020). In the conditions of increasingly intense global competition between enterprises, more and more advanced methods have been sought to enable them to gain a higher position. For this reason, entrepreneurs must make the right decisions and change their operating strategies to maintain their position in the market. According to the considerations of Chaberek (2011, p. 11; 2014, p. 4-6), no activity of enterprises is possible without

the provision of appropriate resources, specifically, without the appropriate logistics services. Citing the above considerations, the objectives of the logistics service can be defined as 5R, which provides: the right resources in the right place, at the right time, at the right cost and in the right amount (Chaberek, 2011, p. 11; 2014, p. 4-6; 2020, p. 35-38). Therefore, all the basic processes of enterprises (production or service) must be supported by the logistic processes. Therefore, these activities are so important in gaining a competitive advantage, especially in the situation of threats in the market, that disruptions in demand and other factors may disturb the activities of enterprises. In this context, reference should be made to the functioning of supply chains (consisting of a commodity chain and a logistics chain), which are responsible for the smooth flow of goods from producers to end customers. The supply chain (SC) can be defined as a set of activities related to the flow and transformation of products and information from the moment of extracting raw materials to delivering the final goods to the customer (Chaberek, 2011, p. 41-43). In this situation, it should be mentioned that the definition of the supply chain should contain more detailed information on the commodity chain and the logistics chain as components of SC. The concept of the commodity chain refers to the total flow of goods. This includes goods in the economy from supplying entities, through production entities, and through distribution entities (Świerczek, 2012, p. 33). The goods chain is thus supported by a logistics chain, which should provide support in accordance with essential logistics. In other words, logistics processes should function in accordance with the idea of logistics (Chaberek, 2011, p. 39).

Effective management is related to the use of various concepts, methods and techniques supporting the organization of activities and decision making. Changes taking place in the economy favor the emergence of new management strategies, which are also adapted to supply chain management. In the literature on the subject, certain trends are indicated in this area, including lean management, agile management or resilience to interference (e.g. Vonderembse *et al.*, 2006; Pisarek, 2018). In view of the above-mentioned, the aim of the study was to characterize three selected concepts that can be used in supply chain management; specifically, Lean Manufacturing, Agile Manufacturing and Resilient Manufacturing. An attempt was made to indicate the essence of selected concepts and the benefits of their application in the management of supply chains in the changing operational conditions of enterprises.

Methodology

The study has a descriptive character. It focuses on selected aspects of management throughout the supply chain, their characteristics, and the benefits of their application. The theoretical description is based on the use of foreign and domestic literature, its criticism and analysis. Additionally, scientific

databases were searched according to the subject of the study to better match the literature review to the presented content. An extensive web-based review was also performed to obtain better information on the benefits of applying different forms of management. Based on the collected literature, a description, analysis, and criticism were made, and then conclusions were presented based on the entire article.

Lean manufacturing

The concept of lean manufacturing (LM) in the modern economy is an important issue concerning enterprises. This is in relation to the pillars of sustainable development, which include economic, environmental, and social aspects (Varela *et al.*, 2019). In enterprises, it is an important tool of the business strategy that enables them to maintain a competitive position (Wahab *et al.*, 2013, p. 1292-1298). The concept was developed in Japan after the Second World War, when most enterprises wanted to maintain high-quality production with limited resources (Bhamu & Sangwan, 2014, p. 876-940). An early adopter of the concept was Toyota Motors, which introduced an automated and flexible production system into its production in the process of producing products of high volume and variety (Sharma *et al.*, 2018, p. 4678-4683). Subsequently, other manufacturers adopted the LM concept focusing on the elimination of waste in the production halls.

Today, lean manufacturing is widely accepted and used by companies to improve overall efficiency. Bhamu *et al.* (2012, p. 288-306) recognize the following as LM goals: quick response to customer requirements, quick delivery times, as well as the efficient and economic production of high-quality products. Muluget (2021, p. 1432-1436) lists the following as the main goals of lean manufacturing: increasing productivity, improving product quality, reducing inventories, shortening lead times, and eliminating production waste. Kainuma and Tawara (2006, p. 99-108) and Bevilacqua *et al.* (2017, p. 769-794) add that the elimination of all unnecessary sources of process losses is aimed at reducing costs, improving efficiency, increasing flexibility, and maximizing the value generated for customers. Berente and Lee (2014, p. 417-433) argue that lean manufacturing is an innovative change. Pettigrew *et al.* (2001, p. 697-713) add that change is episodic and revolutionary, or incremental and evolutionary. Biazzo *et al.* (2016, p. 237-260) suggest that LM offers gradual rather than radical changes. As indicated by Ghobadian *et al.* (2020, p. 457-468), companies using the lean manufacturing concept strive to gradually reduce the amount of waste by introducing structural changes, modifying, or introducing new processes. Pettigrew *et al.* (2001, p. 697-713) additionally mention routine and technological changes. Browning and Sanders (2012, p. 5-19) emphasize that the LM concept

in its present shape works best in enterprises where the demand for products is high, and the process variability is small and can be controlled. Olhager and Prajogo (2012, p. 159-165) confirm that the concept works best for forecast-based mass production. When implementing the LM concept, enterprises should be based on five principles: identifying value, mapping value streams, creating flows, establishing a pull system, and striving for perfection (Tortorella *et al.*, 2021).

There are many tools and practices used in the concept of lean manufacturing (Shah & Ward, 2007, p. 785-805). Jasti and Kodali (2015, p. 867-885) list 26 tools and practices used in LM, while Marodin and Saurin (2013, p. 6663-6680) identify 37 of them. Table 1 describes 12 selected lean manufacturing tools that have been developed to maximize the use of production capacity, reduce cycle

Table 1

Characteristics of selected lean manufacturing tools

Tools	Characteristics
Quality circles	creating a group of employees whose aim is to analyze processes in terms of quality improvement
Kaizen	the Japanese philosophy promotes continuous improvement because of continuous effort and commitment of employees
5's	5's (selection, systematics, cleaning, standardization, self-improvement), a tool used to create and maintain a well- organized and safe work position
Cause and effect diagram	a tool for the graphical illustration of the factors affecting the issue, combined with a storm drain to reach the primary cause of the identified problem
Fmea	the method aimed at the prevention of the effects of defects, which may occur in the stage design and the stage production
Poka-Yoke	method of preventing malfunctions derived from mistakes
SMED	the method of rapid changeover, the shorter the time, the smaller the losses in anticipation of the changeover and machine settings
Just in time	a management method to reduce work in progress and inventory levels in production and warehouse processes
Kanban	it consists in organizing the production process in which each organizational unit produces exactly as much as it is needed at a given moment, while limiting excess stocks and shortages, as well as reducing production and storage space. A maximum and stable production quantity is determined, and the production rate is kept constant
DMAIC	DMAIC (Define, Measure, Analyze, Improve, Control), engineering quality based on the data used in order to streamline processes
Time and movement study	the technique efficiency of the business, combining study time (monitoring time required to complete each phase of activity in the place of work), the study of motion (observe the steps taken by the worker in order to perform actions)
Value Stream Mapping (VSM)	a graphical tool that allows you to visualize and analyze important elements of production processes, making it possible to improve the continuity of material and information flow processes

Source: own study based on Palange and Dhattrak (2021).

times, and increase the value of the product (Sundar *et al.*, 2014, p. 1875-1885). Kolla *et al.* (2019, p. 753-758) emphasize that the effective use of tools depends on their appropriate selection, authenticity of the collected data and employee involvement. Particular attention was paid to Kanban. It should be noted that it was designed as a just-in-time tool. Ohno (1988) described his inspiration as Kanban, or “pull production”, which has become the hallmark of the Toyota Production System. Hopp and Spearman (2004, p. 133-148) add that its goal is to prevent overloading the entire production system while maintaining high production rates and volumes.

The use of the lean concept in supply chains is aimed at achieving efficiency and effectiveness in this aspect. It concerns inter-organizational relations and the creation of processes in each of the links. The main effect of lean manufacturing, which is believed to be the basis for creating a lean supply chain, is to refine the relationship between the links of the chain. As a result, the delivery takes place in the shortest time, at the lowest cost, and the offered product is of the highest quality (Kruczek & Żebrucki, 2011, p. 355-364). The concept of lean manufacturing allows considering the processes implemented in an enterprise from the point of view of material and information flows (Kruczek & Żebrucki, 2011, p. 355-364). Sustainable implementation of lean manufacturing is possible by closely linking the principles of logistics with the methods of managing the quality level in the entire activity of the enterprise, as well as between enterprises. Ciesielski (2006) claims that the LM concept uses the best and most consistent application of logistic principles of thinking and acting. Ciesielski and Długosz (2010) add that LM is considered a new manifestation of logistics, especially in relation to situations that are characterized by a high degree of complexity and dynamics of information and material flows. Flow control methods such as Just in Time, the theory of constraints and TQM are widely used throughout the entire chain. However, it is difficult to use: 5S, Kaizen and TPM methods (Ciesielski & Długosz, 2010). Ciesielski and Długosz (2010), Soltysik (2003) and Wincel (2004) list four stages of implementing the lean concept into the supply chain management process:

- supply chain selection – identifying the chain that will be optimized, setting a reference target, and correlating with chain performance, defining potential first-tier suppliers, planning the scope of cooperation, describing the value stream, determining how each supplier participates in shaping the stream (the procedure is repeated for first- and n^{th} degree recipients); to measure effectiveness: individual cost, delivery time, quality, or a combination of these measures;

- assessment of the current state of the chain – assessment of each supplier and recipient of the first level and the leader (considering previously established benchmarks), compilation and comparison of the changes taking place, carrying out calculations and comparisons for n^{th} level suppliers and customers; the results form a macro description of the effectiveness of the processes carried out in the supply chain;

– defining activities – creating a future state project; the project contains a list of possible measures to be taken to improve the results, proposals should be developed by all participants in the chain;

– introducing changes – developing a plan for introducing projects that improve efficiency, implementing projects, measuring, documenting changes compared to the goals of improving efficiency; changes should be communicated periodically.

Lean manufacturing is all about developing and using a holistic approach to shaping the supply chain. Decisions made based on the LM concept include structural problems (the location of individual chain elements and their placement in the flow structure) and coordination problems (they include establishing partnerships, inventory level planning, production planning, and the scope of information sharing) (Ciesielski & Długosz, 2010). The effects of applying the lean approach in supply chain management relate to the organization of the structure and improvement by streamlining the flows in terms of sections and the entire supply chain.

Agile manufacturing

The constant changes taking place in the economy and society increase the complexity and uncertainty of the functioning of enterprises and pose new challenges to them. The growing expectations of more and more demanding customers in terms of product quality and price, as well as order fulfillment time and delivery flexibility, force enterprises to create value in cooperation with the customer, to increase the ease of adapting to the changes taking place and the speed of response to customer needs (Sajdak, 2013, p. 203). Investing resources in improving efficiency and focusing on continuous improvement of internal work processes will therefore in many cases be insufficient. Agile manufacturing (Ramesh & Devadasan, 2007) may be the answer to such changing conditions in the functioning of enterprises, which is meant to help enterprises become more competitive and prosperous in a demanding environment where changes are unpredictable and continuous (Dowlatshahi & Cao, 2006; Gunasekaran *et al.*, 2017). The concept comes from 1991, when it was described by the so-called Agility Forum, a joint initiative of the US government, industry, and academia. The forum was established to develop a long-term strategy by which American producers could cope with global competition (Ren *et al.*, 2003; Thilak *et al.*, 2015).

There are many definitions of agility in the literature on the subject. According to Shankarmani *et al.* (2012, p. 31-37), it is a readiness to respond to immediate changes in the size and volatility of demand. Moradlou and Asadi (2015, p. 31-44) emphasized that agility is related to the ability to ensure customer satisfaction, constant preparation for market changes, appreciating

information and establishing a virtual enterprise. In the opinion of Dahmardeh and Banihashemi (2010, p. 178-184), an agile producer is an organization with a broad vision for the new order of the business world and with the ability to deal with turbulence as well as to capture beneficial aspects of business. Pan and Nagi (2013, p. 969-983) noted that agile manufacturing creates the boundary between the organization and the market, and that an agile enterprise behaves like a leader, develops affordability, and professionally anticipates changes.

At the strategic level, four key areas that characterize an agile enterprise can be identified (Goldman *et al.*, 1995, p. 59-67):

- customer enrichment – an agile enterprise is one that is perceived by its customers as enriching them in a significant way; this requires a quick understanding of the unique requirements of an individual customer and providing them with a satisfactory product;

- cooperation – inter-organizational and intra-organizational, cooperation with suppliers, establishing virtual relationships with competitors;

- organization – enabling development in conditions of change and uncertainty; flexible, flattened organizational structure allowing for quick configuration of human and physical resources;

- paying attention to human resources, information, and technologies – perceiving employees as extremely valuable assets of the company, placing emphasis on education, training, and empowerment, supporting the entrepreneurial attitude.

Agility in the context of supply chain management consists of the ability to quickly deliver personalized products with unique features to the market in order to maintain a competitive advantage in a changing environment (Ambe, 2010, p. 5-17). An agile supply chain requires flexibility and adaptability, as well as an appropriate flow of information supported by advanced ICT technologies¹.

For the chain to be agile, it must have four practical features to which they belong (Hoek *et al.*, 2001, p. 126-148; Kisperska-Moron & Swierczek, 2008, p. 217-224):

- market sensitivity – obliges us to quickly respond to customer requirements;
- virtual integration – requires companies to exchange information and knowledge rather than inventory;

- process integration (process integration) – suggests that network companies delegate basic production modules among themselves based on their relative competences;

- networking integration – requires that enterprises in the supply chain have a common identity, which may include involvement in agile practices, structure compliance, information architecture compliance and cooperation competences.

¹ The importance of advanced technologies in the case of logistics is described in more detail in the publication Wieczorek (2020).

According to Braunscheidel and Suresh (2009, p. 119-140), agility can be measured based on interdependent dimensions of supply chain maturity, such as business partnership, complementary resource competence, knowledge transfer, and effective leadership. Blome *et al.* (2013, p. 1295-1318) emphasized that an agile supply chain increases the operational efficiency of an organization and is a prerequisite for achieving agile production. Muralidar (2015, p. 145-159) mentioned that some of the agile manufacturing benefits include: short time to market, rapid development of new products, fast order fulfillment, low volumes, low quantities, large selection of products, configurable components, fast deliveries from suppliers, short lead times, short cycle times, highly flexible processes, highly flexible machines and devices, use of advanced CAD/CAM, quick changeovers, and qualified employees.

The agility concept works best in unpredictable environments where the demand for diversity is high and the demand is fluctuating, while the lean concept is best used in environments with high volume, low diversity, and predictability (Tab. 2). Ambe (2010, p. 5-17) believes that lean is needed to build agility. Many authors (e.g., Mason-Jones *et al.*, 2000, p. 4061-4070) emphasize that these two concepts can complement each other, and it is possible to combine them using the advantages of both paradigms (the leagile concept).

Table 2

Lean and agile strategies comparison

Characteristic	Lean strategy	Agile strategy
Objective	cost minimization	customer service level maximization
Typical products	mass goods	fashion goods
Market demand	predictable	changeable
Product differentiation	small	big
Product life cycle	long	short
Customer priority	price	availability
Profit margin	low	high
Dominant costs	production costs	marketing costs
Consequences of stocks depletion	agreeable and delayed in time	immediate and variable
Logistics orientation	waste elimination	customers and markets
Cooperation with partners	fixed and long-term	fluent clusters
Key measures	effect measures, e.g., efficiency and costs	ability metrics and customer satisfaction
Process organization	work standarization, norms compliance	self-discipline-based operator's autonomy
Logistics planning	regular	prompt reaction

Source: own based on Ciesielski (2011).

Resilient Manufacturing

Growing customer expectations regarding product personalization, maintaining a high level of timely deliveries and other requirements make enterprises face a tough challenge to meet these types of requirements. In addition, regardless of whether a given enterprise operates in the production or service industry, they are more and more often disturbed by various types of phenomena, both natural and man-made (e.g., a shortage of appropriate resources, or inadequate information transfer in supply chains). Activities aimed at assessing the company's susceptibility to the occurring disturbances and their possible mitigation led to the achievement of production resilience. This type of resilience can be achieved by implementing measures to return from an undesirable state to a desired state (Kusiak, 2020). Production activities in such a case should be supported by a comprehensive approach to ensure full understanding and modeling of resistance. The full scope of the elements building resilience include: energy, resources, physical processes, transport, communication, productivity, and others (Kusiak, 2019). These elements may prove that a given company will operate within the framework of resistant production, thus creating resilience within the supply chain within which it operates.

The aspect of resilience can also be directly applied to the supply chain. In its general meaning, it defines the possibilities of the supply chain to deal with various changes that may occur in the market (Wieland & Wallenburg, 2013, p. 301). In the literature, this type of supply chain is referred to as a *Resilient supply chain* (What is a..., 2020). In principle, they should be, in accordance with their name, resistant to any anomalies, breakdowns or other problems that may result from changes in the current operating conditions or disturbances in the flow of the commodity chain or logistic chain (being in a service relationship to the former) (Stavros & Epaminondas, 2012, p. 922-924; Negri *et al.*, 2021, p. 5, 6). When this aspect is referred to a manager, it concerns taking actions to limit or reduce the negative impact of the potential occurrence of a disruptive factor (Boin *et al.*, 2010, p. 1-6). From the perspective of a third (observer) person, it is possible to fully determine the efficiency of Supply Chain after a crisis. Specific actions can be implemented before the emergence of a crisis or in response to it (Välikangas, 2010, p. 19).

Achieving resilience in the case of supply chain management is now tantamount to not only the ability to reduce risk, but above all to some forms of risk management, which should lead to a better positioning of enterprises in relation to their competitors. This may even lead to gaining some advantages by using disruptions. In reference to material science, resistance (can also be referred to as elasticity) is the ability of a material to recover its original shape after deformation. In the case of enterprises (especially those in production), this skill refers to the ability to deal with disruptions, e.g., the speed of recovery to a normal level of performance (in relation to production, services, etc.) (Michelman, 2007).

According to Michelman (2007), it is possible to achieve resistance on three main levels. One of the planes concerns „excesses”. In theory, it is possible to create a resilient enterprise by creating excess at different stages of the supply chain through, for example, additional inventory, low production capacity or signed contracts with different suppliers. However, this form of action is limited only to temporary and very costly solutions that cannot be used over a longer period. It is therefore clear that this type of solution should be avoided by focusing on other types of supply chain management (e.g., *Toyota Production System*), where the production efficiency activities of enterprises are demonstrated by maintaining low levels of inventory and delivering the product of the required quality in a timely manner. Meanwhile, redundancy will limit the company’s ability to achieve such performance.

The second level is flexibility that will allow firms to withstand significant disturbances and give a better response time to fluctuations in market demand. The actions a company can take are (Michelman, 2007):

- standardization of production processes involving the use of similar elements, parts, and assembly designs in different factories, which allows for possible quick relocation of production in the event of a disruption;

- the use of simultaneous and not sequential processes in the areas of product development, production, or distribution, which will allow for faster recovery of operations after market disruptions;

- using postponement in such a way that products are finalized only at the last stages of the supply chain when a specific demand for a given product occurs, which will enable better customer service while reducing the costs of maintaining finished goods in the warehouse;

- adjusting the procurement strategy to the current relationship with suppliers, primarily by knowing business partners thoroughly in order to detect a potential problem or in order to rely on them in a situation that requires assistance. (In a situation where the company does not have close links with suppliers, it should have an extensive supply network that will build its resilience and enable dynamic reactions to the situation in the markets).

On the third level, the focus should be on cultural changes. Corporate culture may be the factor that may determine that a given enterprise quickly reverts to its core form of operation after the occurrence of disruptive factors. Such activity manifests itself through (Michelman, 2007):

- constant communication between employees in such a way that they remain aware of the company’s goals and how the company should operate, so that when disruptions occur, employees have the knowledge to make appropriate decisions;

- dispersing the causative power in such a way that teams or individual employees can take appropriate action in a hazardous situation or to prevent the occurrence of this hazard, e.g., during the production process;

- employees' passion for their work, consisting of showing their employees a sense of a higher idea in the performance of their duties and not only in performing "repetitive processes";

- awareness of the occurrence of disruptions, consisting in the fact that resilient enterprises, because of the occurrence of disruptions, seek motivation for innovative and improving activities to better cope with them in the future.

The actions listed are examples that can be undertaken by enterprises. It should be emphasized that the benefits of building "resilient" organizations by creating these types of supply chains are significant. These types of enterprises will not only be able to withstand disruptions, but also gain a competitive position by getting ahead of their competitors as part of a better response to disruptions (Arora *et al.*, 2020).

Summary

The basic activity of production and service enterprises requires appropriate logistics services, including the efficient flow of goods and information, which is ensured by the supply chain. Applying the principles described in concept development to supply chain management can bring many benefits. The lean approach focuses on reducing waste and losses, increasing efficiency, reducing costs and increasing the speed of delivery with the best possible quality. Applying lean in the supply chain allows you to organize the structure and streamline flows. As part of agile, the ability to quickly respond to changes in customer demand and requirements, adapting to external conditions, as well as appropriate information flow and cooperation becomes key. An agile supply chain allows you to improve the efficiency of an organization and leads to the achievement of agile production. The resilient aspect concerns the ability to deal with various changes and disruptions that may occur in the market, the ability to reduce risk, and even gain some advantages by using disruptions. A resilient supply chain is characterized by greater flexibility and the ability to create new connections, learn, and collaborate. The presented directions of changes in the approach to management in supply chains are related to their adaptation to the increasingly demanding operating conditions, which are a consequence of processes taking place in the economy, including increased competition, technological changes, or growing consumer requirements. It is worth noting that apart from the concepts indicated above, the literature on the subject also includes references to a closed-loop supply chain or green logistics. It should be remembered, however, that none of the methods is universal, and the legitimacy and effects of its application depend on the current market situation, as well as the internal conditions of the enterprise. Individual concepts should be treated as complementary, which can create synergy effects.

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